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# Process development of ready-to-eat custard cream filled Chinese steamed bun

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**Abstract**

Glycerol and fructose were added to custard cream filling and glycerol and lactic acid were added to steamed bun to adjust the $a_w$. The optimum condition for custard cream filling was 6% glycerol and 6% fructose and for the steamed bun was 2.5% glycerol and 0.25% lactic acid which reduced $a_w$ to 0.915 and 0.912, respectively. The custard cream filling was combined with bun and packed in PVDC pouch with and without oxygen absorber (OA). It was found that the shelf-life of samples packed with OA was 10 days based on microbial and 8 days based on texture quality.



*Keywords*: Chinese steamed bun; custard cream; hurdle; process development; shelf life extension

## 1. Introduction

Steamed bun is one of the common foods in Asia [1]. Fresh steamed bun has high moisture content and short shelf life of no longer than 3 days. Chilling or freezing is a preservation method considered to be effective to extend its shelf life as can be seen in convenient stores. However, the texture of the bun changes due to low temperature. The hurdle technology has been used to prevent microbial spoilage and food poisoning. Hurdle technology is a combined preservation method by applying different means such as adjusting water activity ($a_w$), pH, temperature, redox potential, modified atmosphere [2]. Several hurdles are used minimally to get the optimum combination in order to achieve good quality products [3,4]. There are several studies using various hurdle parameters to extend shelf-life of high-moisture and intermediate-moisture foods. The shelf-life of Caprine keema, Indian traditional meat product, was extended up to 3 days at ambient temperature by controlling aw and pH at 0.90 and 5.80, respectively [3].

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The pH, $a_w$, and preservative were used to prolong the shelf-life of South African steamed bread [5]. Heat and pulsed electric field were applied to extend shelf-life of low-fat milk to 21 days under refrigeration compared to 14 days of thermally pasteurized milk [6]. Adjusting $a_w$ and pH can affect the sensory quality of food products as well as adding preservation and is limited by the regulations and consumer awareness of healthy products. Since there is no study on shelf-life extension of Chinese steamed bun with custard cream filling (CCSB) this research aimed to study the possibility of extending the shelf-life to about 10 days at room temperature by applying $a_w$, pH, preservation, and modified atmosphere packaging as hurdles.

## 2. Materials & Methods

### *3.1. Effects of glycerol and fructose on quality of custard cream*

Custard cream was prepared according to the adjusted recipe of Poonnakasem [7]. Glycerol and fructose were added at 3- 9% of total adjusted recipe weight. The mixture was mixed using an electric hand mixer (Airlux, HA3127, Canada) at low speed for 5 min and steamed at 100$^{O}$C for 15 min by electric steamer (Hanabishi, HEP-1900S, Thailand). The custard cream was cooled at room temperature to 25-30 $^{O}$C prior to $a_w$ measurement and sensory evaluation. The acceptance test on sweetness, texture, and overall acceptance (OAA) was carried out using 25 untrained panelists.

### *3.2. Effects of glycerol and lactic acid on quality of Chinese steamed bun*

The steamed bun was prepared according to the basic recipe (Table 1). Ingredients in first step were mixed, kneaded, and proofed. The proofed sponge was mixed with the remaining ingredients of second step. Glycerol (0, 2.5, 5%) and lactic acid (0, 0.25, 0,5%) were added and kneaded before forming into round shape. Each bun (25 g) was further proofed and then steamed at 100$^{o}$C for 10 minutes by an electric steamer. The steamed bun was cooled to room temperature (~25-30$^{o}$C) prior to aw, pH measurement, and preference test on appearance, flavour, texture and overall acceptability (OAA) using 25 untrained panelists.

Table 1. Recipe of Chinese steamed bun

| | Ingredients | Amount (% weight) |
|---|---|---|
| First step | Cake flour | 38.3 |
| | Reversed osmosis water | 19.7 |
| | Sugar | 3.3 |
| | Yeast | 1.6 |
| Second step | Cake flour | 16.4 |
| | Sugar | 8.0 |
| | Reversed osmosis water | 6.6 |
| | Shortening | 3.3 |
| | Cakes emulsifier | 1.5 |
| | Baking powder | 1.1 |
| | Salt | 0.4 |

### *3.3. Effect of calcium propionate on shelf-life of Chinese steamed bun*

Calcium propionate (CaP) at 0-0.2% was added in the second step of preparation of Chinese steamed bun with the chosen levels of glycerol and lactic acid. The samples were packed individually in 13x17 PVDC pouch and stored at 30 $\pm$ 2°C until spoiled. Samples were taken every 2 days to be analyzed for $a_w$, pH, and aerobic plate counts, yeast and mould plate counts.

### *3.4. Effect of packaging conditions on shelf-life of CCSB*

The dough and custard cream were prepared according to the chosen conditions found above. The custard cream filling was filled into the bun before second proofed. The custard cream filled dough was steamed, cooled at room temperature to 25-30 °C, packed individually in 13x17 cm PVDC pouch, sealed with and without $O_2$ absorber (OA) and stored in an incubator at 30±2 °C until they spoiled. Samples were taken every 2 day for $a_w$, pH measurements and microbial analysis. The experiment was carried out in 2 replicates. Independent sample t-test was used to analyze the data. For texture measurement, samples were taken every 4 days.

### *3.5. Statistical analysis*

The analysis of variance (ANOVA) was performed to test the significant effect of each variable. Student's t-test was used to compare the difference between mean and the optimum conditions of each case were determined from the response surface method (RSM).

## 3. Results & Discussion

### *3.1 Effects of glycerol and fructose on quality of custard cream*

From ANOVA it was found that all response variables except texture depended on glycerol, fructose and interaction between glycerol and fructose. The $a_w$ of custard cream was found to decrease with increasing glycerol and fructose due to their excellent water-binding properties (Table 2). Sensory scores increased with an increase in glycerol and fructose up to around 6% and then decreased *($p \leq 0.05$)*. From the RSM (Fig. 1) it was found that the optimum levels of glycerol and fructose were 6% each.

Table 2. Effects of glycerol and fructose on qualities of custard cream

| Glycerol (G, %) | Fructose (F, %) | $a_w$ | Average sensory score* | | |
|---|---|---|---|---|---|
| | | | Sweetness | Texture | OAA |
| 3 | 3 | 0.947±0.001$^{g}$ | 6.43±0.18$^{cd}$ | 6.08±0.06$^{b}$ | 6.26±0.13$^{b}$ |
| 6 | 3 | 0.931±0.001$^{f}$ | 6.02±0.06$^{bc}$ | 6.51±0.15$^{cd}$ | 6.48±0.06$^{bc}$ |
| 9 | 3 | 0.926±0.000$^{e}$ | 5.89±0.31$^{b}$ | 5.72±0.17$^{a}$ | 6.32±0.30$^{bc}$ |
| 3 | 6 | 0.930±0.002$^{f}$ | 6.84±0.08$^{d}$ | 6.75±0.11$^{de}$ | 6.97±0.06$^{e}$ |
| 6 | 6 | 0.915±0.002$^{c}$ | 7.51±0.21$^{e}$ | 7.08±0.15$^{f}$ | 7.45±0.06$^{f}$ |
| 9 | 6 | 0.905±0.002$^{b}$ | 6.59±0.11$^{d}$ | 6.27±0.16$^{bc}$ | 6.56±0.06$^{cd}$ |
| 3 | 9 | 0.920±0.000$^{d}$ | 6.45±0.35$^{cd}$ | 5.75±0.12$^{a}$ | 6.33±0.20$^{bc}$ |
| 6 | 9 | 0.903±0.002$^{b}$ | 6.61±0.01$^{d}$ | 6.92±0.02$^{ef}$ | 6.78±0.13$^{de}$ |
| 9 | 9 | 0.893±0.000$^{a}$ | 5.10±0.42$^{a}$ | 5.66±0.06$^{a}$ | 5.79±0.11$^{a}$ |

* 10 point line scale (0 = dislike very much; 10 = like very much)
Means with different superscripts in each column are significantly different *($p \leq 0.05$)* and ns is not significantly different *($p>0.05$)*

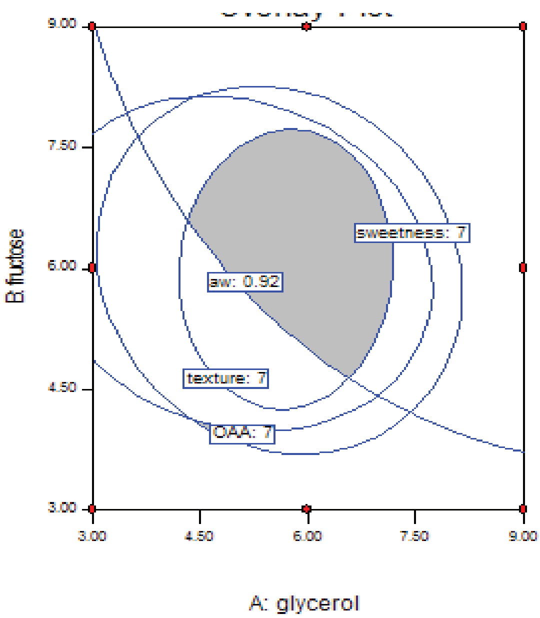


Fig.1 Overlay plot of response variables of custard cream

### *3.2. Effects of glycerol and lactic acid on quality of Chinese steamed bun*

From the ANOVA it was found that only glycerol affected $a_w$ while only lactic acid affected pH. Thus the effect of each additive was analyzed separately. Table 3 showed that the $a_w$ decreased significantly as glycerol increased from 0 to 5% ( $p \leq 0.05$) presumably due to the lowering free water in the dough [5]. The pH and all sensory quality except appearance of the bun did not changed significantly with glycerol ($p > 0.05$). The appearance of the bun with 2.5% glycerol was not significantly from control (0% glycerol and lactic acid). For lactic acid, it was found that $a_w$, appearance, and texture did not change significantly ($p>0.05$) while pH, flavour and OAA of bun decreased as lactic acid increased. The bun with 0.25% lactic acid had preference score on flavour and OAA not significantly different from control. Therefore glycerol at 2.5% and lactic acid at 0.25% were chosen.

Table 3. Effect of glycerol on $a_w$, pH and sensory qualities of Chinese steamed bun

| Glycerol (%) | $a_w$ | pH $^{ns}$ | Average sensory score* | | | |
|---|---|---|---|---|---|---|
| | | | Appearance | Flavour$^{ns}$ | Texture$^{ns}$ | OAA$^{ns}$ |
| 0 (control) | 0.916±0.008$^{c}$ | 5.83±0.44 | 6.80±0.67$^{b}$ | 6.28±0.97 | 6.55±0.58 | 6.60±0.80 |
| 2.5 | 0.905±0.007$^{b}$ | 5.83±0.47 | 6.84±0.29$^{b}$ | 6.26±0.64 | 6.52±0.17 | 6.55±0.33 |
| 5.0 | 0.880±0.011$^{a}$ | 5.86±0.47 | 6.17±0.15$^{a}$ | 6.06±0.62 | 6.42±0.78 | 6.39±0.67 |

* 10 point line scale (0 = dislike very much; 10 = like very much)
Means having different superscripts in a column are significantly different ($p \leq 0.05$) and ns is not significantly different *($p>0.05$)*

Table 4. Effect of lactic acid on $a_w$, pH and sensory qualities of Chinese steamed bun

| Lactic acid (%) | $a_w$ $^{ns}$ | pH | Sensory score* | | | |
|---|---|---|---|---|---|---|
| | | | Appearance$^{ns}$ | Flavour | Texture$^{ns}$ | OAA |
| 0 (control) | 0.900±0.021 | 6.35±0.12$^{c}$ | 6.65±0.51 | 6.63±0.21$^{b}$ | 6.57±0.38 | 6.82±0.24$^{b}$ |
| 0.25 | 0.902±0.022 | 5.83±0.08$^{b}$ | 6.80±0.56 | 6.52±0.61$^{b}$ | 6.66±0.33 | 6.79±0.38$^{b}$ |
| 0.50 | 0.899±0.010 | 5.34±0.08$^{a}$ | 6.35±0.43 | 5.45±0.58$^{a}$ | 6.27±0.79 | 5.93±0.60$^{a}$ |

* 10 point line scale (0 = dislike very much; 10 = like very much)
Means having different superscripts in a column are significantly different ($p \leq 0.05$) and ns is not significantly different *($p>0.05$)*

### 3.3. Effect of CaP on shelf-life of Chinese steamed bun

The results showed that $a_w$ and pH of the buns did not change significantly (p>0.05). From microbial analysis (Table 5) the AC increased slightly with storage time. Samples kept for 16 days still had AC lower than 4.00 log CFU/g which implied that they are safe to consume. There was no yeast and mold detected in all samples. Thus addition of CaP may not be needed to prolong shelf-life of the HP-treated steamed bun.

The HP buns were prepared without CaP and stored at 30 $\pm$ 2$^{o}$C and were taken every 4 days for texture measurement and sensory evaluation on OAA using 9-point hedonic scale. The correlation between subjective and objective measurement was determined. It was found that only hardness and gumminess could correlate with the sensory score as followed: Hardness = -6.48(OAA) + 52.50 ($r^2$=0.85), Gumminess = -3.50(OAA) + 27.91 ($r^2$=0.96)

Table 5. Effects of hurdle and preservative on microbiological properties of Chinese steamed bun

| CaP (%) | AC (log CFU/g) at storage period in days | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0$^{ns}$ | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 |
| 0 | 1.7±0.0 | 1.8±0.2$^{a}$ | 2.5±0.5$^{b}$ | 2.7±0.2$^{a}$ | 2.6±0.3$^{a}$ | 2.4±0.1$^{a}$ | 2.4±0.6$^{a}$ | 2.8±0.7$^{b}$ | 3.3±0.2$^{ab}$ |
| 0.1 | 1.8±0.2 | 1.7±0.0$^{a}$ | 1.9±0.3$^{a}$ | 2.4±0.6$^{a}$ | 2.4±0.33$^{a}$ | 2.1±0.1$^{a}$ | 2.5±0.5$^{a}$ | 3.1±0.1$^{b}$ | 3.4±0.1$^{b}$ |
| 0.2 | 1.8±0.2 | 1.7±0.0$^{a}$ | 1.8±0.2$^{a}$ | 2.4±0.6$^{a}$ | 2.5±0.43$^{a}$ | 1.7±0.0$^{a}$ | 1.8±0.2$^{a}$ | 1.7±0. 0$^{a}$ | 2.8±0.5$^{a}$ |

Means with different superscripts in a column are significantly different ($p \leq 0.05$), ns of AC is not significantly different ($p$>0.05)

### 3.4. Effect of packaging conditions on shelf-life of CCSB

It was found that AC of all samples significantly changed after 2 day storage ($p \leq 0.05$) (Table 6). The AC of CCSB without OA increased rapidly and was about 7 log cfu/g on the 8$^{th}$ day, while the AC of CCSB with OA was only 4.9 log cfu/g on the 10$^{th}$ day because OA can reduce the oxygen in the package so the growth of aerobic microorganism was inhibited[8]. Therefore the CCSB with and without OA was safe up to 10 days and 4 days storage. Furthermore, yeast and mould could not be detected. The $a_w$ of bun and cream of CCSB were separately analyzed and found to remain constant throughout the 16 day storage ($p > 0.05$). For pH, the CCSB with and without OA samples were not significantly different ($p > 0.05$)

during storage. Therefore, the treated CCSB packed with oxygen absorber was safe up to 10 days from microbial spoilage and was chosen for further study.

From the textural measurement (Table 7), it was found that storage time had no effect on the springiness of the sample. The cohesiveness of the stored sample was significantly decreased as found in bakery products [9]. Hardness and gumminess significantly increased from 9.09 to 16.72 N and 5.12 to 7.28 N, respectively. The sensory score of the stored samples was estimated from the correlations and were found to decrease from 6.70 to 5.52 and 6.52 to 5.90 for hardness and gumminess. As the sensory score of the 8$^{th}$ day stored sample was about 6 which was the acceptable value, so it could be concluded that the storage life of the hurdle- treated CCSB was extended to 8 days.

Table 6. Effects of hurdle and modified atmosphere on microbiological properties of CCSB

| Treatment | AC (log CFU/g)at storage period in days | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 2 | 4* | 6* | 8* | 10 | 12 | 14 |
| HP | 1.8±0.1 | 3.0±0.4 | 4.6±0.6 | 6.8±0.4 | 7.2±0.1 | - | - | - |
| HP + OA | 1.8±0.2 | 2.9±0.3 | 3.1±0.4 | 4.2±0.2 | 4.3±0.1 | 4.9±0. 1 | 5.6±0.1 | 5.8±0.1 |

* in each column is significantly different ($p \leq 0.05$)

Table 7. Textural measurement of hurdle CCSB stored in a package with OA

| | Texture values at storage period in days | | | |
|---|---|---|---|---|
| | 0 | 4 | 8 | 12 |
| Hardness (N) | 9.09±0.39$^{a}$ | 11.03±0.45$^{b}$ | 15.01±0.56$^{c}$ | 16.72±1.87$^{d}$ |
| Springiness$^{ns}$ | 0.91±0.01 | 0.90±0.01 | 0.90±0.01 | 0.91±0.01 |
| Cohesiveness | 0.56±0.05$^{c}$ | 0.51±0.02$^{bc}$ | 0.49±0.02$^{ab}$ | 0.43±0.05$^{a}$ |
| Gumminess (N) | 5.12±0.69$^{a}$ | 5.68±0.19$^{a}$ | 7.35±0.29$^{b}$ | 7.28±1.76$^{b}$ |
| Sensory score (OAA)* (1) | 6.70±0.06$^{b}$ | 6.40±0.07$^{b}$ | 5.79±0.01$^{a}$ | 5.52±0.27$^{a}$ |
| (2)$^{ns}$ | 6.52±0.16 | 6.36±0.06 | 5.88±0.04 | 5.90±0.51 |

* Estimated sensory score from hardness (1) and gumminess (2)
Means having different superscripts in a row are significantly different ($p \leq 0.05$) and ns is not significantly different ($p$>0.05)

## 4. Conclusions

The CCSB process was developed to produce the shelf-stable product using hurdle technology. The optimum levels for custard cream filling were 6% glycerol and 6% fructose which resulted in reduction of $a_w$ to 0.915 and the highest sensory score. Addition of 2.5% glycerol and 0.25% lactic acid reduced $a_w$ and pH of Chinese steamed bun to 0.912 and 5.78, respectively, and the sensory qualities were not significantly different from the control. Based on microbiological test, this hurdle-treated bun could be stored for at least 16 days at 30±2$^{O}$C without preservative, while the control bun could be stored for only 4 days. The hurdle-treated CCSB with oxygen absorber in PVDC packaging could be stored for at least 10 days at 30±2$^{O}$C without microbial spoilage. But after storage for 8 days, the texture was unacceptable. From the microbiological and textural viewpoints, the shelf-life of the developed CCSB was extended from 3 days to at least 8 days at room temperature (30 ± 2$^{o}$C).

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